

ART. V.—*The Physiography of the Koo-wee-rup Swamp.*

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### Introduction.

The Koo-wee-rup Swamp, or Great Swamp as it was termed on early maps, is situated in the low-lying alluvial terrain between the foot-hills of the Eastern Highlands and the head of Western Port Bay. Reclamation of the Swamp was commenced in 1885, and no detailed account of its original condition is extant. Traverse notes of surveyors and the meagre information available from other sources indicate that the central part of the swamp was covered with water in which grew rushes and reeds (probably *Phragmites communis* and species of *Scirpus*), and that the marginal land was more complex, with tea-tree (*McLaleuca ericifolia*) in damp depressions between low sand ridges, and water channels in places. East (1935) remarks that "The soil of the swamp itself consisted of fibrous peat, 6 to 10 feet deep, water-logged for the most part . . . an ideal haven for wild fowl, deer and wombats". Since peat was formed over the whole of the central portion of the swampland, it is clear that anaerobic conditions existed there, and as mentioned above, it is known that there were areas of standing water in which grew the *Phragmites* and other plants of which the peat is composed (see Goudie, 1942). Yet the swamp has a fall throughout its length, ranging from 3 feet per mile in the lower reaches of the main drain to 10 feet per mile near Bunyip. Hence there can have been no continuous standing water-body of the dimensions of the swamp, and it is suggested that the central portions consisted of relatively small lake-like cells, separated by dense growths of rushes and reeds which acted as slowly permeable barriers to the flow of surface waters, while the bottom water moved even more slowly through a spongy mass of peaty soil. Where sand ridges rose above the level of the swamp (as they did in places, being used as natural routes into it) they aided in the impendence of drainage. The area of deep peat (Goudie, 1942, Plate X.) lies between the sandy complex of the Bayles district (parts of which were above swamp level), the alluvial flats of the Yallock Creek (which likewise were outside and probably at a higher level than the swamp), and the alluvial fans of the Lang Lang River and King Parrot Creek on the east. Here drainage towards the coast was particularly slow, and a large area of standing water may possibly have existed. The waters of the swamp were derived mainly from the Bunyip River, the defined channel of which could formerly be followed for about 2½ miles south of the Bunyip township, before it became

dissipated within the swamp. To-day the Bunyip waters are carried by the main drain, which is scouring deeply in the north, and aggrading in the south around Koo-wee-rup (see East, 1935, for further details of the reclamation scheme).

Shrinkage of the peat deposits of the swamp has resulted from drainage, oxidation of carbonaceous material, wind erosion, consolidation by trampling during farm work, and in places from burning, so that considerable subsidence has taken place since the swamp was reclaimed. The extent and magnitude of this are indicated on the map (fig. 1), and it may be seen by reference to the soil-map prepared by Goudie, that significant subsidence is restricted to the actual paludal area in which peat occurs. The maximum amount of subsidence, about 8 feet, took place where the peat deposits were deepest, and no subsidence can be detected on non-peaty areas such as the alluvial flats bordering the Yallock Creek. East (1935) has pointed out that the underlying clays did not shrink appreciably on draining.

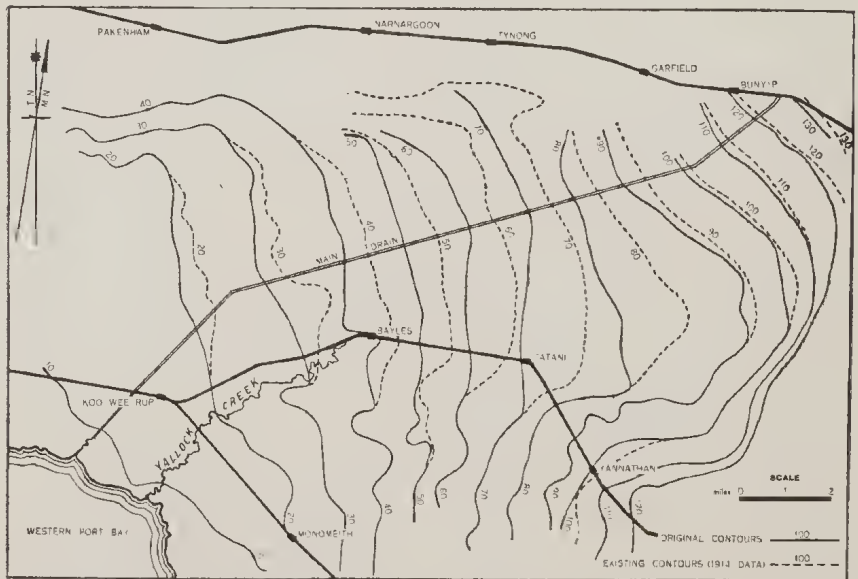


FIG. 1.—Topographic map of the Koo-wee-rup Swamp, from data supplied by the State Rivers and Water Supply Commission. Existing contours are shown where they differ from the original contours as a result of subsidence.

### Topography.

The alluvial terrain in which the Koo-wee-rup Swamp is situated has the topographic form of a half-basin which may be referred to as the Koo-wee-rup Basin. This is bounded on the east by the Heath Hill Scarp, which trends N.N.E. from Grantville to Longwarry, and marks the western edge of the South Gippsland Highlands. From Heath Hill northwards the scarp is composed of Older Volcanic basic lavas, but south from Heath Hill these are covered by late Tertiary sands, clays, and gravels,

which also extend westwards from the scarp towards Lang Lang and reach the coast at the Red Bluff, Lang Lang Beach. The northern rim of the basin is formed by the foothills of the Eastern Highlands, long spurs from which extend southwards between the broad alluviated valleys of south-flowing streams. On the west, the plain of the Cranbourne district, composed of Tertiary sands, gravels, and Older Volcanic rocks with isolated inliers of Silurian bedrock, passes gradually beneath the alluvial deposits of the basin (see fig. 5). The broad valleys of insignificant streams such as Clyde Creek carry tongues of alluvium into the plain, and outlying hillocks of Tertiary sands are in places surrounded by alluvial deposits. In the south, these deposits merge into the tidal mudflats at the head of Western Port Bay.

### **The Coast.**

In the neighbourhood of Quail Island, the sandy plain of the Cranbourne district reaches the sea, and in this district long tidal inlets known as creeks extend inland between low hills composed of Tertiary sands and sandy clays. Salt marshes and mangrove swamps border the mud-bottomed tidal channels. The range of spring tides in Western Port is 8 feet, with low water mark 2 feet below low water mark, Hobson's Bay, and the salt marshes lie at or slightly below storm-tide level. Cliffs cut in the soft Tertiary sediments are suffering rapid erosion by tidal scour. This stretch of coastline, it is clear, originated as a result of the submergence of the edge of the Cranbourne plain, which adjoins the Koo-wee-rup Basin on the west. The "creeks" are drowned valleys in which natural reclamation by siltation in mangrove swamps and salt marshes is now in progress.

The long, branching tidal channels known as "The Inlets", lying to the east of Tooradin are, however, of a different nature. They traverse gently-sloping alluvial flats that are, with the exception of one or two small areas, below storm-tide level, and were, before the building of levees, periodically inundated by the sea. In plan, the Inlets show a dendritic pattern of branching channels, each representing a self-contained drainage unit which is long compared with its breadth, and they present a remarkable similarity in form to the rill-marks that develop on sloping surfaces of water-saturated sand or mud, such as may be seen on beaches at low tide (fig. 2). Each rill is a miniature dendritic drainage system of the order of a foot or a yard in length, the main channels of some examples being meandrine, and of others, fairly straight (see Chamberlin and Salisbury, 1905, figs. 325, 326).

The physiographic setting of the Inlets is directly comparable with the conditions under which rill-mark is developed. They arise at the edge of, and serve to drain the formerly water-saturated alluvium of the Dalmore Swamp and the south-westerly trending terminal "arm" of the Koo-wee-rup Swamp. The channels were fed by seepage from this saturated alluvium, and

it is suggested that they have become permanently fixed in position as a result of tidal scour. At present, owing possibly to the acceleration of siltation consequent upon the carrying of large amounts of detritus into the Bay by the drains, the Inlets are silting up. Sawtell's Creek differs from the Inlets in its remarkably meandrine course. Aerial photographs (Plate IX., fig. 2) show that the meanders have undergone normal shifting as with river meanders, but the head of the main creek is in the south-western part of the Dahmore Swamp, and the defined channel does not carry on through the Swamp to link up with a normal stream course in the north. It is, therefore, clear that Sawtell's Creek, though differing from the Inlets in its strongly meandrine course is, like them, merely a seepage channel fed by drainage from a swamp. It may be noted that the pattern exhibited by the channels in the tidal flats at the head of Western Port Bay closely resembles that of the Inlets and of Sawtell's Creek (fig. 2). At first sight this might suggest that the Inlets are upraised tidal scour-channels, but since they are still subject to tidal inundation this explanation is inadequate.

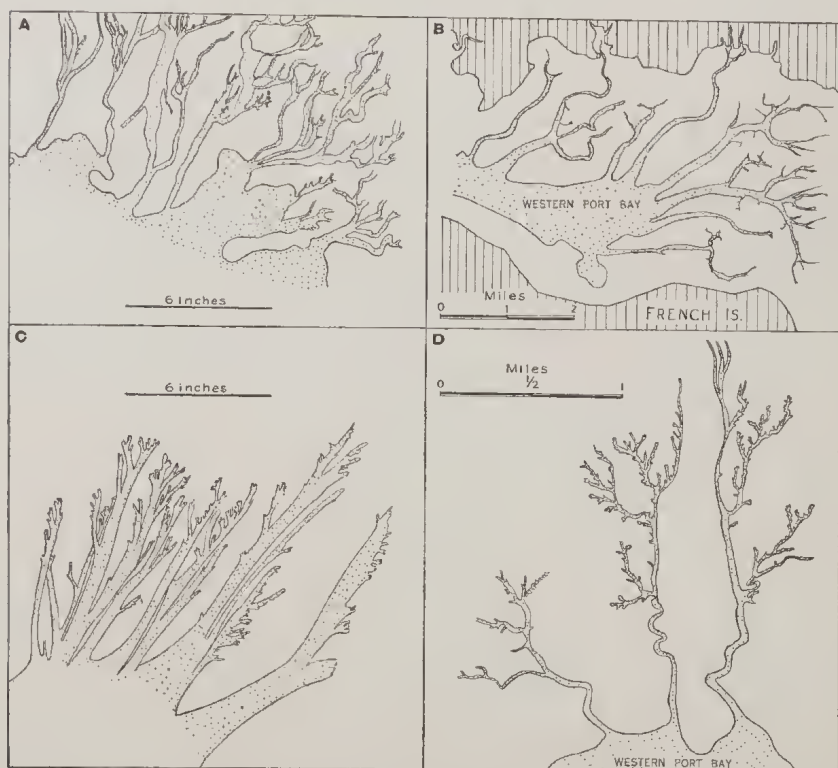


FIG. 2.—Diagrams to show the analogy in plan of rill-mark (A and C), tidal channels in mud-flats at the head of Western Port Bay (B), and the Inlets, east of Tooradin (D).

A. and C after Chamberlin and Salisbury (1905), scale approximate only; B. after the Admiralty Chart; D from a survey by the State Rivers and Water Supply Commission.



East of the Inlets, the coastline is not indented as it is to the west. The alluvial flats bordering on the Yallock Creek, for example, slope gently towards the sea, and terminate in a low cliff about 3 feet high, over which storm-tides flood. The cliff and the tidal flats off-shore at this point have been excavated in the fluvatile flood-plain deposits, chiefly dark clay with dispersed grit particles, laid down by the Yallock Creek (fig. 3). This creek is the natural outlet to the eastern portion of the Koo-wee-rup Swamp, but it differs from the Inlets in that it does not itself traverse swamp land.



FIG. 3.—Mouth of Yallock Creek at low tide, showing the low cliff and "shore platform" cut in alluvium.

At the Red Bluff on Lang Lang Beach, Tertiary sands, grits, and clays reappear in the cliff sections, and the physical features of the coast change. The seaward face of the Red Bluff is still undergoing marine erosion, but to the north and south the coastline is prograding. Stockyard Point, on the south, is a broad complex of sand-ridges with intervening swales, built up just above normal high tide level, but still subject to marine incursions during storms. The ridges are beach ridges, aeolian sand drift being subordinate because of the presence of vegetation and the numerous swampy swales. When submergence first occurred, a low marine cliff was formed in the soft Tertiary sands and sandy clays of the Red Bluff ridge, but as a result of the formation of successive sand ridges, which were probably initiated as barrier-beaches trending north and south from the headland, this cliff has been removed from the influence of marine erosion,

and is now flanked by an "apron" of small alluvial cones and fans, which merge into the lagoonal deposits formed behind the sand ridges at high tide level.

In the Grantville district, submergence brought the sea into contact with the alluvial cones and fans derived from the Heath Hill Scarp. Low cliffs about 6-8 feet high were cut in the outer edges of the fans, and as a result the streams that formerly migrated freely over them in the course of aggradation were rejuvenated, and are now incised in fixed channels on the fans. This effect is of considerable importance in the interpretation of changes of sea-level relative to the land as judged by the condition of streams, for it leads to the unexpected result that under certain circumstances rejuvenation may result from submergence. After the above events had gone on, normal progradation at storm tide level took place, especially in the bay-heads, and thus the coast from Grantville northwards is now fringed with a low-lying ridge and swale complex, behind which is the initial coastline formed on submergence (fig. 4).

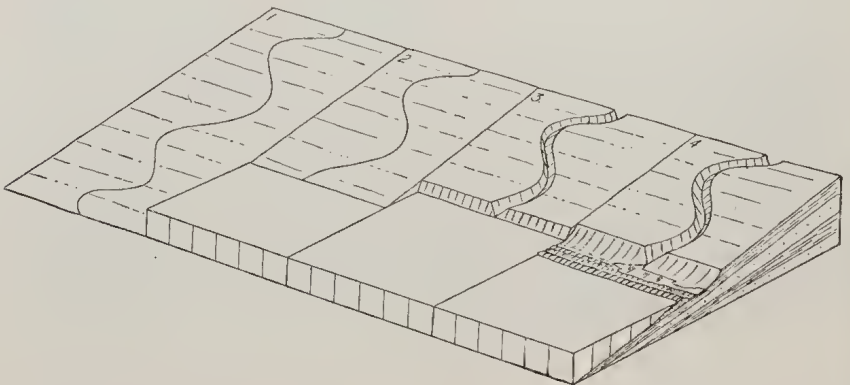


FIG. 4.—Block diagram to illustrate the sequence of events in the evolution of the coast near Grantville. (1) Stream depositing alluvial fan, before submergence; (2) submergence; (3) cliffing and rejuvenation of the stream; (4) progradation, and wasting of the former marine cliff.

It will now be clear that there is no evidence, in the region of coastline investigated, for any Recent emergence such as has been recorded in Port Phillip Bay (Hills, 1940). The last major event in the physiographic history of the coast-line at the head of Western Port Bay was submergence. While it is tempting to regard this as due to the post-Glacial eustatic rise of sea level advocated by Daly, there is little evidence to support this idea.

The submergence of the flood plain deposits of the Yallock Creek, and of the alluvial fans at Grantville, suggests rather that the marine incursion was a local phenomenon of Recent date, caused by tectonic depression of the Koo-wee-rup Basin. This conclusion, of course, does not in any way affect the conception

that there very probably was a previous post-Glacial eustatic rise of sea level. The important question of whether submergence is still in progress is also difficult to decide. All that can be said is that north of Grantville, tea-tree grows to the water's edge, where it is dying, probably as a result of the immersion of its roots in salt water. Peaty clays laid down after the original submergence at this point are now exposed on the beach between low and high-water mark, and there is, therefore, a suggestion that submergence may still be in progress. The evidence available is, however, not conclusive, since the level at which these deposits formed is not known with certainty.

### The Koo-wee-rup Basin—Geological History.

The geological history of the Koo-wee-rup Basin during Cainozoic times may be commenced with the development of the pre-Older Volcanic terrain. This land surface was formed on Silurian sedimentary rocks, Palaeozoic granites, and Jurassic sedimentary rocks, and appears to have been of little-diversified relief, though well-defined river valleys existed. In pre-Batesfordian (Oligocene?) times, impure brown coals, sands, and clays were laid down, and the Older Volcanic lava flows were extruded. During the Miocene a marine incursion, recorded by the presence of *Lepidocyclina* limestones overlying lignites in bores at Tyabb, indicates a partial submergence of the area beneath the sea (Bore Records, 1919-22 (1929), p. 28). At Cardinia, too, *Lepidocyclinae* have recently been obtained at about 150 feet below the surface in a bore (Allotment 4, Section A.1, in the Parish of Pakenham). Mr. W. J. Parr has kindly supplied the following information on this discovery:—

“Description of Material: Light-coloured foraminiferal sand (in parts cemented) with frequent rounded grains of quartz. In addition to the foraminifera, there are large specimens of a calcareous alga, *Lithothamnium* sp. (the largest with a diameter of  $1\frac{1}{4}$  inches) and worn bryozoans.

#### List of Foraminifera:

*Gypsina globulus* (Reuss).

*Gypsina howchini* Chapman.

*Amphistegina* sp. aff. *haucrina* d'Orbigny.

*Lepidocyclina* (*Nephrolepidina*) *hamiltonensis* Chapman and Crespin.

Remarks: The foraminifera, particularly *L. (N.) hamiltonensis* and *Gypsina howchini*, fix the age of the bed as Batesfordian. The same species occur at Flinders and in the Hamilton district (Clifton Bank, the red limestone on the Grange Burn, and in the Mines Department bore). The specimens are very well developed. A good many are worn; this evidence of rolling and

the presence of the rounded sand grains indicate that the deposit was laid down close to the shore line." The foraminiferal sand is underlain by a decomposed Older Volcanic basalt.

This marine incursion was followed by the deposition of some 300 feet of late Cainozoic sands, gravels, and clays of continental facies, which covered a wider area than the present Koo-wee-rup basin, since they extend on to the Heath Hill fault block in the Nyora district and also over parts of the Mornington Peninsula, especially in the north. Although the provenance of these deposits has not been determined, it is most probable that they were derived from highlands in the north, this indicating a probable tilting—the highlands rising and the region to the south subsiding. After the deposition of these continental sediments, faulting and warping occurred, probably in Middle and Upper Pliocene times, the block to the east of the Heath Hill Scarp being relatively uplifted, and the Koo-wee-rup Basin depressed. As will be clear from the geological cross-section (fig. 5), the western block is tilted, inclining downwards towards the east.

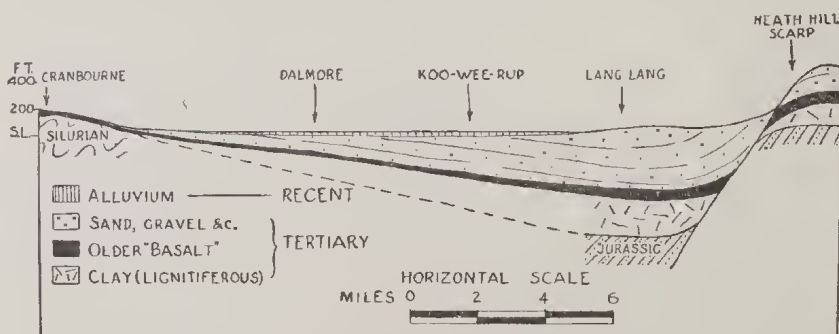


FIG. 5.—Sketch geological cross-section, from Cranbourne to the Heath Hill Scarp, through Koo-wee-rup.

The Heath Hill Fault dies away to the north of Picnic Point on the main Gippsland road, and also to the south, beyond Grantville, its maximum throw being in the neighbourhood of Heath Hill. The downthrown block to the west, while exhibiting an easterly tilt, is also warped about an E.-W. axis, so that the Older Volcanic rocks that pass beneath Tertiary sands in the north, reappear in the south of French Island. The existence of a westerly salient projecting from the Heath Hill scarp towards Lang Lang and the Red Bluff suggests, too, that subsidiary east-west warp axes or faults may have been concerned in the elevation of these Older rocks in the south, but to establish the position of these axes boring would be necessary. It is, however, clear that the bedrock surface beneath the Koo-wee-rup Basin is itself a true tectonic basin, in which Cainozoic sedimentation has gone on from pre-Older Volcanic times until the present day.



After the completion of the differential movements that determined the major features of the existing topography, most of the Tertiary sands and gravels were eroded off the higher land. The stripping of these deposits from the southern edge of the Eastern Highlands has revealed the formerly buried terrain of Older Volcanic lava residuals and bedrock ridges, which pass below the Tertiary sedimentary rocks of the basin. The Cranbourne sand and its equivalents in other localities (see Holmes, Leeper and Nicholls, 1940) which form a covering sheet over the underlying more argillaceous continental Tertiary deposits, is a dominantly fluvatile deposit, very probably derived in large measure from uplifted portions of the Older Tertiary sediments. On the sandy plains brought into existence during this period of erosion and deposition, aeolian activity gave rise to sand hills in places, as, for example, on the Tooradin Road near Fisher's Road.

As the penultimate stage in the evolution of the Koo-wee-rup Basin, before the advance of the sea, may be pictured the deposition of broad, low alluvial fans by streams debouching from the marginal higher land on the north, west, and east, and also from the site of French Island, which had not yet been separated from the mainland.

The evidence above advanced from the study of the present shoreline indicates that the swamp deposits had probably already been laid down when the marine incursion took place, and they continued to form until the swamp was reclaimed.

### **Origin of the Koo-wee-rup Swamp.**

In relationship to the origin of the Koo-wee-rup Swamp, several points have to be elucidated. Firstly, it should be noted that there was only one episode of peat formation, which persisted at Koo-wee-rup up till the time of reclamation. In the Dalmore Swamp, however, the period of peat-formation was followed by the deposition of black clay. As the deposits of these two swamps are continuous, it is clear that the cessation of peat deposition at Dalmore was brought about by some local physiographic change that did not affect the Koo-wee-rup district. This suggests that a drainage modification affected the streams feeding the Dalmore Swamp, and there is evidence that a change of this nature did occur.

Aerial photographs reveal in the St. Germain's district the former existence of stream courses, extending from near the eastern end of O'Connor's Road south-easterly to St. Germain's and "Carajon" (see Military Survey, Cranbourne Sheet). These old stream courses are quite independent of the Cardinia Creek, as they lead back to the low divide near "Gwenhurst", at the head of the creek that flows north-westerly from there to the Hallam Valley flats. The meanders have larger radii of curvature than those of the present Cardinia Creek, and it is quite certain

that a larger creek than this formerly flowed over the St. Germain's country, towards the Dalmore Swamp (Plate X., fig. 1).

This stream has now vanished, probably as a result of the reversal of its upper regions by depression of the country to the north-west of "Gwenhurst". The small creek now flowing north-westerly from that point has an extremely low gradient, and its outlet to the Eumemmering Creek is an artificial drain only. Thus the indications are that the Dalmore Swamp formerly received considerably larger supplies of water than it now does. It is suggested that during this period the peat accumulated, then with the sudden reduction of water supply, the conditions became unsuitable for peat-formation; swamp tea-tree invaded the area, and the superficial black clay was deposited. The tea-tree persisted until the district was cleared and drained, its presence indicating that the permanently anaerobic conditions with a continual cover of surface water such as must have existed when the peat formed, had given place to a somewhat drier but still swampy environment.

It may be concluded from the history of the Dalmore Swamp, as well as from the recorded facts that tea-tree grew on the fringe of the Koo-wee-rup Swamp while the peat deposits formed in standing water in the central parts, that the initiation of peat-formation followed an increase in the supply of water to the site of the swamp. This probably resulted from a climatic change involving either an increase in precipitation or a decrease in evaporation, especially as regards the summer months. Whichever factor was dominant, and of course both may have changed, it appears very probable that an increase in the ratio of precipitation to evaporation was the prime cause of the initiation of a peat-forming environment.

In any discussion of possible changes in the conditions of the streams entering the basin, the sand and gravel deposits in the "sandy complexes" (see soil map by Goudie) must be considered. Although the areas so mapped by Goudie contain most of the sand and gravel deposits associated with swamp, there are also scattered sand ridges in those parts mapped as the "normal peaty phase" of the swamp, and if the reports of local residents are reliable, certain of these ridges were used as routes along which cattle could be driven into the swamp, to forage on the sedges. It is, therefore, clear that some at least of these ridges were not related to river courses then in existence, but must be older than the adjacent swamp deposits. In some places, indeed, peat overlies sand ridges, and the latter are necessarily older. Furthermore, the sandy complex near Bayles is not connected at the surface with the northern sandy complex, although sand ridges continue from it, parallel to the main drain, for some miles towards Bunyip. Any modern stream, in order to deposit this

sand, would have had to "ferry" it across the swamp, an impossible condition in view of the fact that some of the gravels near Bayles contain pebbles  $\frac{1}{2}$  inch in length.

It therefore appears that the deposition of the Bayles sandy complex ante-dates the formation of the swamp. The northern complex, too, is not connected with the course of the Bunyip River by surface sand deposits. Along its northern edge is a strip of peaty soil that was formed in a local swamp fed by the streams to the west of the Bunyip River, and hence is probably younger than the sandy complex that blocked these streams in the south.

The available information, therefore, indicates that the bulk of the sandy complexes was laid down before the swamps were formed, and they very probably represent the higher portions of an old alluvial fan deposited by the Bunyip River. As the stream wandered over its growing fan, particular strips in which it held its course for a relatively protracted period would be built up, and between these, shallow depressions with finer grades of alluvial deposits would remain. During the formation of the sandy complexes the Bunyip River was actively aggrading, and was supplied with coarse detritus, especially from the granitic terrain in its headwater region.

These conditions suggest that the climate at the time was more arid than at present. With a lower P/E ratio, much country that is now completely vegetated may have been relatively barren, and the granites would have weathered by crumbling into their component mineral grains. The Bunyip River would have had a smaller total flow than it has to-day, but during floods large amounts of detritus would have been moved from the hills and deposited in the aggrading reaches of the stream in the Koo-wee-rup Basin. At the same time the Lang Lang River and other streams entering the basin would have experienced similar conditions. Sand ridges, now vegetated, that were deposited by the Cardinia Creek extend for at least 3 miles beyond the termination of the natural channel of the stream, but the present stream is capable of carrying sand thus far and even further, since it has been confined in an artificial channel.

The Bunyip River, too, is capable of transporting sand of the same coarseness as that in the sandy complexes, out into Western Port Bay. Hence the (apparent) cessation of formation of the sandy alluvial fans that attended the initiation of the swamps involved more probably an increase in precipitation than a decrease. As a result, vegetation fixed much of the sand and gravel of the fans, the catchment became more densely vegetated, and the supply of sand and gravel decreased. The immediate run-off from the hills was reduced, but the delayed run-off increased, which aided in making formerly intermittent streams permanent, an important factor in the alimentation of the swamp.

As these changes progressed, it is suggested that swamp tea-tree first established itself on the lower and wetter parts of the alluvial fan. With the establishment of a permanent water supply to these parts, however, the tea-tree was killed and its place taken by reeds and rushes, growing in the lake-like cells referred to above. Thus were finally established the anaerobic conditions under which the peat accumulated.

As Twenhofel points out (1926, p. 576), "The development of peat in swamps checks the drainage of an already poorly-drained surface and also hinders evaporation. The level of the water rises and the swamp expands laterally. This expansion may result in the entire surface becoming swampy."

During floods, the fringing tea-tree acted as a barrier to the water, through which it could penetrate only slowly. Through any gaps in the tea-tree barrier, currents probably carried a little sand and gravel into the swamp, so that, with changing conditions in the barrier, the whole of the swamp may have at different times received small amounts of such coarse detrital material. This accounts for the presence of sand and gravel particles dispersed throughout the clays of the swampy areas.

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### Explanation of Plate.

#### PLATE IX.

- FIG. 1.—Aerial photograph showing the former stream courses in the St. Germain's district. Approximate scale 1 inch = 70 chains. (R.A.A.F. photo.)
- FIG. 2.—Aerial photograph of the Tooradin district, showing Sawtell's Creek and the tidal mudflats at the head of Western Port Bay, at low tide. The dark vegetation-zone around the coast is mangrove swamp. ("Airsby" Regd., photo.)



